Generation X

Attitude Control Systems (ACS)

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ACS Overview

- Requirements
- Assumptions
- Disturbance Torque Assessment
- Component and Control Mode Recommendations
- Major ACS Issues and Concerns
- Recommended Trade Studies
- Risk Assessment

ACS Requirements

- Pointing Requirements
  - Boresight Pointing Accuracy: < 1 arc-second
  - Boresight Pointing Knowledge: 0.5 arc-sec
  - Drift or jitter: < 1 arc-sec/minute

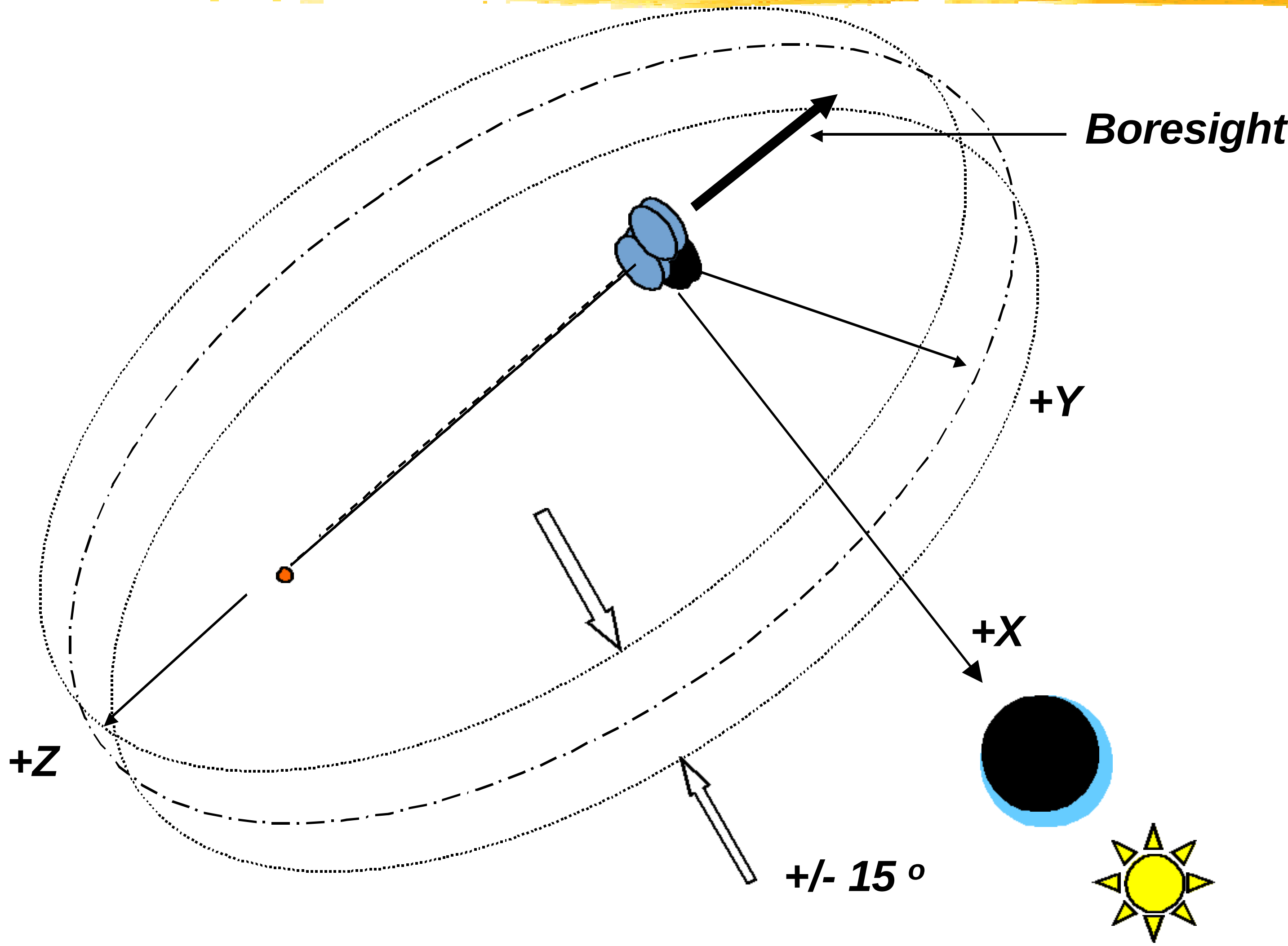
ACS Assumptions

- **Coordinate System:** origin at center of mass
- X toward sun, Y transverse, +Z toward detector
- **Moments of Inertia ($kg\text{-}m^2$)**

	Stowed	Deployed
X	13320	680000
Y	13320	680000
Z	22500	22500

- **Effective Area** 30 m^2
- **Low-earth Orbit:** altitude = 400 km, Inclination: = 51 degree
- **Science Orbit:** L2
- **Science Attitude** +X pointed near the sun. Boresight pointing
- restricted to 0.0 +/- 15 deg from the sun.

Attitude Geometry



ACS Disturbance Torque Assessment

- Gravity Gradient Torque at LEO:
    - With Boom stowed: 0.017 Nm
    - With Boom Deployed: 1.200 Nm
    - (at L2 gravity gradient is negligible)
- Aerodynamic Torque at LEO:
    - With Boom stowed: 0.012 Nm
    - With Boom Deployed: 0.292 Nm
- Solar Pressure at L2
    - Torque:
        - With Boom stowed: 1.4×10^{-6} Nm
        - With Boom Deployed: 1.0×10^{-3} Nm
    - Momentum buildup per day:
        - With Boom stowed: 0.12 Nms
        - With Boom Deployed: 86.5 Nms

ACS Component Recommendation

Components	Model	Quantity	Cost ($K)	Mass (Kg)	Power Orbit Avg (W)	Power Peak (W)
ACE	(Based on Map)	2	2000	16	22	26
Coarse Sun Sensor	Adcole 11866	8	48	0.0368	0	0
Digital Sun Sensor	Smex lite, 40560	2	400	1.76	1.4	1.4
IRU	Litton SIRU	1	1000	5.44	22	40
Star Tracker	CT-602	2	13000	11.804	0	10
Reaction Wheel	Explorer, in house	4	1600	70.92	28	440
		Total =	**18048**	**105.961**	**73.4**	**517.4**

- Based on current technology meeting mission requirements
- Future technology should enhance performance

ACS Component Placement

- Wheel should be located as close to the center of mass as possible to reduce wheel induced jitter
- Four wheels can be arranged in a pyramid to provide “boosted” torque in the major slewing axis as well as redundancy.
- Star tracker and gyros should all rigidly mounted with respect to the critical alignment surface.

ACS Control Mode Recommendation

- **Rate null/Sun acquisition -** Null the rate and point solar array normal to the sun.
- **Delta H mode -** Perform delta H to unload wheel momentum
- **Delta V mode -** Slew to burn position and perform delta V
- **Science mode -** 3-axis stabilized with boresight axis (Z) perpendicular to sun-spacecraft line (ecliptic plane) +/- 15 degrees, use reaction wheels for slewing and pointing.
- **Safehold mode -** Use CSS and wheel to point solar array normal to the sun, similar to sun acquisition

ACS Issues and Concerns

- Boom bending due to thermal loads and vibration.
- Non-collocated actuator and sensor in the pointing loop can be a source of instability, e.g., Sensing at the detector while moving the optics.
- Rotation of the entire spacecraft about the Z axis is directionally unstable in the presence of energy sinks.
- Symmetry of X and Y axis moment-of-inertia should be maintained to prevent oscillatory motion around Pitch axis.

ACS Options Considered

♦ Spinning the optics for thermal stability was considered

- The large moment-of-inertia of the optics and an acceptable spin rate for thermal stability leads to an angular momentum too large for target-to-target maneuvering with wheels.

- A large counter-rotating mass is a possible solution keeping the spacecraft zero momentum biased.

ACS Recommendations for Future Study

- Detector on boom or separate spacecraft for detector
- Worse case two axis slews
- New technology wheel - larger rotor inertia and small dynamic and static imbalance

ACS Risk Assessment

- ♦ Boom length adds complexity to mission
  - Solar pressure torques
  - Torsional bending
  - Non-collocated sensors and actuators
  - Interference of control bandwidths (0.1-0.05 Hz) and structural modes (~0.2 Hz)

- ♦ If Dual Spin utilized can create instability